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Roles of Academia in Supporting Eco-Design in Small Companies for Better Environmental and Economic Performance

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Abstract

Development and diffusion of new or improved products and services is key to solve sustainability challenges such as climate change, resource depletion and loss of biodiversity. Small firms are important for developing these new solutions, but because of resource constraints they normally have to seek external support from e.g. academia and consultancy firms. This paper discusses how academia can provide such support (e.g. knowledge transfer, assessments and new perspectives) in an effective and efficient manner. To illustrate this, three examples of firms, two monitored over a long period of time, are described using interviews, previous evaluations and project reports for data collection.

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Keywords: Product and Service Development; Sustainability; Knowledge transfer; Capacity building; Environmental Assessment

1. Introduction

Development and diffusion of new (environmental) products and services (among many other measures) can help solve some of the environmental problems faced by the industrial world. New products and services are realized in a large diversity of organizations, including companies of various size and character. This paper focuses on small firms for several reasons. First, Geels *et al.* [1] argue that more radical innovations often occur in technological niches dominated by small actors. Second, small firms are often mentioned as having special needs in relation to business support and constitute a large portion of the business sector. Different methods and tools can be used to support environmentally-driven development, further termed as eco-design. The aim with eco-design is to, through better design (via analysis and synthesis), reduce the overall environmental impact throughout the entire life cycle (compare e.g. with Sakao and Fargnoli [2]). In this article, eco-design is used as a broad term encompassing classical eco-design activities such as life cycle assessments, material choices, product service systems design, and business model innovation.

As reported by Baumann *et al.* [3], a large number of eco-design tools exist. Le Pochat *et al.* [4] argue that such tools mainly solve technical problems and guide design choices, but in the case of a small firm, are not permanently integrated in the core business of the firm. A lack of customer focus in eco-design is noted by Sakao and Fargnoli [2], who suggest communication of user value and environmental benefits and mass customization for making eco-design more successful.

Product and service development is strategically important for the development of a firm, yet Gibb and Scott [5] note the absence of formal planning models in small firms. Even when the development is strategically important, much of the planning is iterative and not formalized. This is rather far from the linear and structured models often presented in textbooks (see Ulrich and Eppinger [6]) and how most eco-design tools are constructed.

Academia is one important actor developing methods and supporting small companies in their eco-design activities. In this article we discuss how academia can provide such support (e.g. knowledge transfer, capacity building, assessments and new perspectives) in an effective and efficient manner to gain better environmental and economic performance of small companies and their products. The article is based on interviews and document studies of three small companies actively working with eco-design over a long period of time together with Linköping University (LiU).

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2. Theoretical Background

To discuss our results and experiences we mainly use terminology from the innovation literature. Central terms are briefly explained below.

Invention vs. Innovation – These terms are connected but not the same. An invention can be defined as *a unique or novel device, method, composition or process*. An innovation means *something 1) new with a high-level of originality, 2) in whatever area 3) that also breaks into (or obtains a foothold in) society, often via the market, and 4) means something revolutionary for people* [7]. There exist various types of innovations, e.g. regarding the focus (e.g. product, service, process, position and paradigm) but also the magnitude (e.g. radical and incremental); a type relevant for this paper, however, is disruptive innovations [8-10], i.e. those that create a new market and value network and eventually disrupt an existing market and value network, thus displacing established market leaders and alliances [10].

Inventor vs. Entrepreneur – An inventor and an entrepreneur share some characteristics; the main difference between an inventor and entrepreneur, however, is that the former is focused on novel tangible inventions, whereas the latter is focused on converting these inventions into successful products, services and businesses [8, 9].

According to many researchers [8, 9], entrepreneurs have different combinations of features and mindsets that e.g. support their ability for action, discipline, comparative thinking (to incorporate others' solutions), flexibility (to change), hypothetical thinking (to re-evaluate e.g. an existing product), ingenuity, finding new channels, identifying niches (needs and wants), radical thinking, serendipity (to identify opportunities), speed, and the ability to manage multiple agendas.

According to Schumpeter, entrepreneurs are not necessarily motivated by profit but regard it as a standard for measuring achievement or success [11]. Instead, they greatly value self-reliance, strive for distinction through excellence, are highly optimistic, and always favor challenges of medium risk.

The Design Paradox – The early stages of a development process have a high impact on the final result [12-14], a situation sometimes called the design paradox. Figure 1 shows the principal relationship between freedom of action, product knowledge and modification cost and is a further development of three figures: the design paradox [12], costs allocated early but used late in the project [15], and the cost for design changes as a function of time during the planning and production process [16].

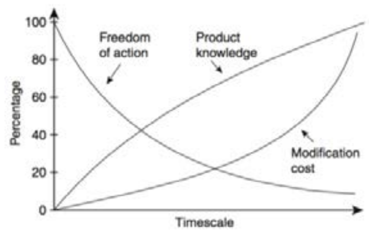

Fig 1. Illustration of the design paradox [14]

3. Methodology

To illustrate and discuss different approaches that academia can use to support companies in eco-design, we describe three companies actively working with eco-design in collaboration with LiU, and who have done so for a long period of time. Information was collected using semi-structured interviews, previous evaluations and project reports.

Since both authors of this paper have been involved in several collaboration projects with the studied companies, two independent interviewers conducted the interviews in order to lower the potential bias impact. The interviews were guided by a set of questions aimed at describing how the firm has cooperated with academia, outcomes of the cooperation, how they perceived the cooperation, and if they had any improvement suggestions. The interviews were held face-to-face between the 5th and 9th of February 2016; all were recorded and transcribed by the interviewers. Respondents (see Table 1) were chosen with the aim to retrieve a broad perspective of each firm's experience.

Table 1. Respondents' company and positions at the company.

#	Company	Position
1	HTC	Håkan Thysell (founder and ex-owner)
2	HTC	Karl Thysell (former R&D Manager)
3	HTC	Robert Kreichberg (Sales Manager)
4	HTC	Peter Lundgren (current R&D Manager)
5	HTC	Per Sandström (Sales Manager)
6	Qlean	Petra Hammarstedt (founder, CEO and owner)
7	Qlean	Peter Hammarstedt (founder, R&D and Sales Manager)
8	Qlean	Håkan Pettersson (Service Technician)
9	Qlean	Erik Träff (President of the Board)
10	Againity	David Frykerås (founder, CEO and owner)
11	Againity	Joakim Wren (founder, R&D Manager and owner)

Based on the collected information, each firm's development and experience regarding cooperation with academia was described, and a cross-case analysis was performed to identify similarities and differences between the studied companies. Further, a list of different roles academia can take in supporting eco-design was constructed and analyzed to find improvement suggestions. The article aims to give examples of such roles rather than providing a statistical overview of how this phenomenon occurs, which would have called for another empirical approach.

4. HTC Sweden AB

4.1. Background

Innovation – HTC Sweden AB (HTC) was founded in 1987 as a construction firm. Soon the founder experienced a lack of suitable grinding equipment to renovate customers' concrete and stone floors. This inspired the firm to develop its own machines, and after some years to start production and sales. At that time, the firm consisted of 6 people.

During a project in 1996, HTC got the opportunity to push the development of diamond tools and grinding methods forward, and its technique was greatly refined. This opened up an opportunity for completely new areas of use for concrete flooring in industrial and public premises. The result was a totally new flooring concept, HTC Superfloor™, which was released in 1997. The technique for polished concrete flooring at this point mainly consisted of grinding the concrete floor with water, but fast development of the diamond tools soon led to the dry grinding methods utilized today. Polished concrete flooring is now introduced to architects, concrete producers, construction companies and facility owners on a global market. HTC has grown to become the world-leading provider of floor grinding equipment; an example can be seen in Figure 2.

HTC has continued to develop and innovate. For example, the firm has come up with new innovations such as improved grinding tools and machines, remote-control of grinding machines and a new technique for industrial dust vacuum cleaners that can manage asbestos particles.

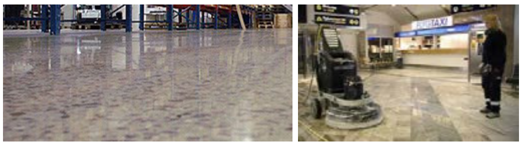

Fig 2. HTC Superfloor and a HTC floor grinding machine.

Based on the founder's experience in the cleaning sector during the 1970s and 1980s and HTC Superfloor™ customer feedback, a second important innovation, Twister™, was developed. Instead of chemical-based floor cleaning, the firm invented a way to mechanically clean and at the same time polish floors using only water and diamond impregnated cleaning pads. The international launch of the Twister concept occurred at the International Sanitary Supply Association show in Amsterdam in 2006, but even if the interest from the market was huge, it took some time for the sales to really take off. Today, many of world's largest cleaning contractors, retail chains, hospitals and other businesses use Twister™ in their daily cleaning, and it is used on e.g. ceramic tiles, linoleum, vinyl/plastic, natural stone, wood and polished concrete.

Ownership – Starting as a family business, in 2006 the founder family sold 36.5% of its ownership to 3i Group, a risk capital company, and 3.5% to private individuals related to the firm. In May 2013, the firm was sold to a Danish-Swedish venture capital firm, Polaris Equity, which at that time managed around €650 million in two investment funds.

Economic development – Yearly sales (MSEK:profit MSEK) were as follows: 2005 (160:13), 2008 (317:5), 2012 (370:23) and 2014 (353:-8). In 2008, the firm employed 170. The export rate at the time was 85%. In 2014, a total of 156 employees worked within the Swedish part of the firm. HTC has offices in Sweden, the United Kingdom, Germany, France, and the United States.

4.2. University Collaborations

HTC has been involved in numerous university collaboration activities, e.g. Advantage Eco-design, student projects (project courses and master's theses), research projects, evaluations, strategic collaboration agreements, and new business development projects. A few important examples are listed below:

Advantage Eco-design (2002-2004) **–** In this project LiU worked together with regional business development organizations in supporting small companies in eco-design. HTC took part in the project and developed a new generation of grinding machines focusing on design and material choices, design for maintenance, and the efficiency of the grinding technology. Of great importance for the coming eco-design activities at the company was the learning that the most important environmental benefit of HTC´s activities was the improvement of the customer's activities.

Life Cycle Assessment of Floor Care (2009) **–** This study was initiated and performed by LiU, and with the aim to, through a Life Cycle Assessment, evaluate the Twister™-method's environmental pros and cons in relation to other traditional floor care methods [17].

Via Futura and Via Futura Concretis (2013-2016) **–** The purpose of these two ongoing research projects are to, based on HTC's patented and world-leading concrete floor grinding techniques, develop methods to improve the surface of asphalt and concrete roads. The aim is to provide greater driving safety, reduce wear and particulate emissions, reduce fuel consumption, and to be economically and environmentally beneficial [18]. Linked to this, business models to facilitate diffusion of the method are developed aiming to reduce the societal costs of road-based transport.

5. Qlean Scandinavia AB

5.1. Background

Innovation – The firm was established in 2002 under the name Servicestaden i Linköping AB. Its initial focus was on cleaning glass facades without chemicals, and in order to do this, the two founders invested in a machine from UK producing deionized water. Quite immediately, they started to manipulate their deionized water machine in order to get even better quality and by chance a groundbreaking invention was made; they discovered that the clean water also immediately dissolved oil. In this context, it is relevant to note that neither of the founders had any higher academic education in chemistry and were not aware that polar solvents (like water) do not dissolve nonpolar substances (such as oil). In 2004 they sent in their invention to the national Swedish competition "Best Environmental Innovation". They were rejected at an early stage because of the "impossibility" of their invention. After sending in reference objects and having direct contact with the organization behind the competition they were reevaluated and came in second place.

In 2005 the firm's founders formed the business area known today as Qlean Construction. In 2007 they received funding for their first major product development projects in collaboration with LiU – which later resulted in Qlean Industry (See 5.2).

In the years since, they have continued to further develop their unique water purification method, and in 2009 received three prizes related to their innovations emerging from the purified water invention.

In 2010, aiming for an international market, the firm changed its name to Qlean Scandinavia AB (Qlean). Today it operates in Sweden, Norway and Denmark and consists of three business areas: Surface, Construction and Industry.

All business areas are based on the firm's technology to produce extremely purified water [19]. When the purified water comes into contact with dirt, it not only loosens e.g. algae and exhaust fumes, but also functions equally well on removing e.g. grease, oil, fingerprints and flux. Currently it is used for cleaning e.g. building exteriors, large transformers, oil-contaminated stones, and hydroelectric dams, as well as cleaning industry components and printed circuit boards (PCBs) before various forms of surface treatment.

To meet its potential customers' needs, Qlean has invested heavily in product development in many areas. Most of this has been done in close collaboration with LiU, which has enabled the firm to test and evaluate its products in an impartial and professional manner (see Section 5.2). It has also enabled the firm to get some of its product development financed by grants from national funding agencies such as Mistra, the Swedish Foundation for Strategic Research, and Vinnova, the Swedish Innovation Agency.

Ownership – One of the founders is the sole owner.

Economic development – Yearly sales were as follows: (MSEK:profit MSEK): 2005 (1.3:-0.2), 2010 (8.0:0.5), and 2014 (25.9:1.4). The firm has been a gazelle company for four years (2012-2015).

5.2. University Collaborations

As mentioned above, Qlean has been involved in numerous activities, e.g. Environmentally Driven Business Development (MDPU), Solvent-Free Industrial Qleaning (SofIQ), Intelligent Qleaning (IQ), Mistra REES, HUS, Växthus, Green Business Model Innovation, numerous student projects (project courses and master's theses), and strategic collaboration agreements. The following are a few examples of these:

Solvent-Free Industrial Qleaning, SofIQ (2008-2010) **–** Within this project, the Qlean method was evaluated and further developed with partners like Flextronics, AkzoNobel and Swerea IVF AB. Equipment was installed and integrated within existing cleaning equipment for PCBs at Flextronics International AB (see Figure 2). Before, more than 10% of the PCBs were discarded; today, that figure is less than 1% [19]. In the life cycle cost (LCC) calculations made in this project it was found that the Qlean method is three times less expensive than the conventional cleaning method with detergents.

Intelligent Qleaning, IQ (2012-2016) **–** The objective of this project was to develop physical demonstrators of universal industrial cleaning machines (see example in Figure 3) using Qlean's water instead of traditional cleaning methods using e.g. detergents, alkaline baths, high temperature and high pressure. Partners have included e.g. Electrolux, Swerea IVF, SECO Tools, and Flextronics International.

In situ cleaning of oil-contaminated stones (2011-2014) **–** The overall aim was to develop an in situ cleaning method and business model for oil-contaminated stones. This project was carried out through a mix of student project work and senior academic work at LiU.

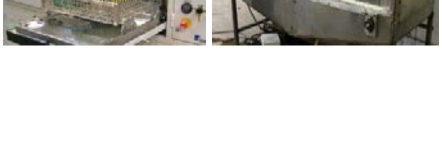

Fig 3. *Left:* Traditional cleaning equipment using Qlean water at Flextronics. *Right:* Demonstrator developed within IQ.

6. Againity AB

6.1. Background

Innovation – Againity is a startup established in 2013. The founder had previous experience in biodiesel production and created a successful firm selling small-scaled biodiesel production plants. That firm was sold after some years to a large multinational company, and the founder sought new business ideas.

The idea behind Againity is to utilize excess heat in the form of exhaust gases from incineration or hot water to generate electricity. The basic idea of the firm's solution is to use an ORC (Organic Rankine Cycle) which passes through a unique power-generating turbine. Using its technology, the output from existing power generators can be increased by up to 20%, solar thermal systems can be used for generating electricity, and excess heat from different processes can be turned into electricity. ORC is a well-established technology in itself, and thus the innovation and business idea of Againity is more focused on the robustness and cost-efficiency of its solution due to its unique power generator.

Ownership and development – The firm is privately owned by its founder, a researcher from LiU and a marketing director. Since it is a recent start-up, we have no long-term data regarding its economic development. In 2014, the firm had one employee and a turnover of 150,000 euros, but increased to eight employees in the beginning of 2016. Recently, the firm signed a contract worth four million euros. Againity has received a number of prizes for its innovation and business idea, and is currently listed as one of the 33 most promising young companies in Sweden.

6.2. University Collaborations

As a start-up, Againity has not been involved in that many cooperation projects compared to the other two cases. The founder, however, had a long history of cooperation with LiU from the time with his former company. When starting his new business, he contacted LiU and asked for support on some technical issues. This contact resulted in the team being complemented with a second owner, also active as a teacher and researcher at LiU. Thus, university collaboration was already in place at an early stage. Againity has recently joined the EU Interreg project "Växthus", in which the company is developing its customer offerings together with 20 other small companies, supported by LiU and business development agencies.

7. Interview Results

The three firms have had various collaborations with LiU (table 2). In common for all the respondents is that the most memorable collaborations, that have been the most beneficial, are the student theses and projects. Furthermore, the research projects have also been memorable and given the firms a higher credibility with a third party's validation of their techniques' or products' results. Many respondents wish to dedicate more time to these kinds of collaborations with the university.

Table 2. Different forms of collaborations mentioned by the respondents

Collaborations	Againity	HTC	Qlean
Guest lectures in courses	X	X	X
Student course projects	X	X	X
Thesis project – bachelor		X	X
Thesis project – master	X	X	X
Minor Field Studies	X		
Recruitment from LiU	X	X	
Research projects	X	X	X
Collaborations with other universities		X	X

All respondents in the study have had a positive experience regarding the collaboration with the university, and declared that it has been valuable in various ways. All participants agree that the collaborations have contributed or will contribute to the firm's economic development in the future, although it is hard to define the degree of the economic impact. Collaborations that have contributed to the economic development are mostly the projects concerning product development in some way, and this mainly concerns Againity and Qlean, but also HTC to a minor degree. HTC instead conveys that the research reports have had a major impact on its selling process. These reports verified the positive results of HTC's products and contributed to the argumentation's reliability when selling certain business concepts. For example, one report that has been very beneficial for the firm dealt with a life cycle analysis for the products within the division of HTC Twister. Some of the respondents from HTC also felt that publications together with the university had improved the firm's visibility and credibility.

Qlean has had collaborations with LiU during almost a decade and a majority of the firm's existence. A big part of the collaborations have been shorter projects with students and have contributed to the development of products, where many of the respondents mentioned the on-going project regarding the development of an industrial washing machine. These collaborations and other university collaborations have also contributed to improve the firm's internal processes, the firm's visibility, and its long-term strategic planning.

In contrast to Qlean, Againity is a start-up and has only collaborated with the university for a couple of years. Despite the shorter period of time, Againity has had various collaborations. Both respondents emphasize the minor field studies, where students examined the firm's market opportunities in Rwanda and Tanzania, as favorable. Moreover, the respondents mentioned that the many student collaborations had been beneficial for the product development, and that these projects have also resulted in the company recruiting some students.

When it comes to improving the collaboration between innovative firms and LiU, the firms in the study convey that the hardest part is to initiate the collaboration. Firms without any connection to the university might feel that it is a big step to even make contact, and according to some respondents a major reason for this is the lack of knowledge about who to contact and what the university has to offer. Some suggestions in the interviews were that the university should invest more resources regarding its contact with the business sector, and to facilitate this communication, dedicate one person to handle these contacts. Another obstacle with the communication that was brought up is the language, as the academic language differs from the language used in firms, which creates a barrier. This barrier causes problems for both the initiating collaborations and within the various ongoing collaborations, and thus complicates the communication, making it hard for the companies to understand the staff of the university.

8. Discussion and Conclusions

8.1. Collaboration Activities

The described cases highlight a number of roles academia can take to support small firms in the area of eco-design. Table 2 shows that in many cases, student work in courses and thesis projects is a common approach. In addition, the cooperation has been in the form of research projects and through recruiting students and researchers from academia to work in the firm. From the case descriptions, different forms of business development projects (not direct research) can be added to the list. Student activities are attractive as a start of the cooperation due to their low cost and risk, which reduces the investment of money and time for both parties compared to long-term research or business development projects. The latter forms most often require external funding, which adds a number of barriers such as complicated application processes and extended periods of time between application, decision and start of the project. However, such projects can lead to more long-term changes in the design of the products and business activities of the companies.

Looking at the aim of different instances of cooperation gives the picture that this has involved activities, often in combination, such as technology development and inventions (e.g. by improving the technologies and applying them in new contexts, see e.g. in situ cleaning of oil-contaminated stones), new product design, business model development, life cycle cost analysis, life cycle assessments, verification including mathematical models, and chemical analysis.

8.2. Support at different stages of the innovation process

When analyzing participating firms, for example, it becomes evident that they have and have had different needs regarding academic eco-design support at different stages of the innovation process, from invention to innovation and dissemination. All three firms described in this article were started by entrepreneurs, with a high capacity to turn inventions into innovations. However, a common challenge for the firms to do so has been to verify and improve the environmental and economic performance of such inventions and innovations (see e.g. life cycle assessment of floor care).

Environmental performance assessments in particular have been troublesome, since this type of verification has until recently been of less interest in industry, compared to economic evaluations. The knowledge of how to conduct and interpret this type of assessment has been low, both among providers and customers. Thus, academic, third-party analysis perspectives and opinions with a strong reputation have been important for the entrepreneurs. For natural reasons, the verification and assessment components have been more critical when the firm was young and their innovations were still new to the market.

When firms reach a more mature level, their innovations start to gain momentum in market uptake, and the need and focus is changed more to further development of the existing innovations as well as finding new innovations based on their original or further refined inventions. These types of collaborations between academia and firms often seem to have a more long-term perspective, e.g. via research projects like Via Futura. However, academia's role as a third-party assessor continues to be important.

It should be noted that much cooperation reported in this article has involved the early phases of innovation, and less in the diffusion phases. Such activities would involve business model innovation and marketing activities to a larger extent than reported in this article. Successful uptake of environmental innovations often requires new business models, capturing the often large-scaled systems changes required and the wider societal values delivered [20].

9. Concluding Discussion

This paper has presented and discussed how academia can provide support to small firms (e.g. through knowledge transfer, capacity building, assessments and new perspectives) in an effective and efficient manner. An innovator/entrepreneur and an academic person's personality can sometimes be seen as the antithesis of each other. Typically, innovators/entrepreneurs want to achieve fast answers and move forward, while academics want to analyze and deepen their knowledge. However, if respecting each other's different personalities and needs, it is possible to achieve fruitful collaborations, as described in the examples from the firms.

The cases described in this paper highlight a number of collaboration approaches, where student activities (e.g. in courses and thesis projects) are attractive as a start of the cooperation due to their low cost and risk, which reduced the investment of money and time for both parties. Other forms often require external funding, which adds a number of barriers but often more long-term changes in the activities of the firm.

Regarding academic eco-design support, new firms generally need academic support to turn their inventions into innovations, especially when it comes to reliable environmental and economic evaluation of their performance. Instead, more mature firms need more eco-design support on further development of their existing innovations, and to find new innovations based on their original or further refined inventions. However, academia's role as a trustful assessor remains. Business model innovation for better uptake of environmental innovations seems to be an area for future activities for academia and entrepreneurs to engage in.

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References

[1] Geels FW, Hekkert MP, and Jacobsson S (2011) *The Dynamics of Sustainable Innovation Journeys*. Abingdon, Oxon, UK, Routledge.
[2] Sakao T and Fargnoli M (2010) *Customization in Ecodesign: A Demand-side Approach Bringing New Opportunities?* The Journal of Industrial Ecology, 14(4): p. 529 - 532.
[3] Baumann H, Boons F, and Bragd A (2002) *Mapping the green product development field: engineering, policy and business perspectives.* Journal of Cleaner Production, 10(5): p. 409-425.
[4] Le Pochat S, Bertoluci G, and Froelich D (2007) *Integrating ecodesign by conducting changes in SMEs.* Journal of Cleaner Production, 15(7): p. 671-680.
[5] Gibb A and Scott M (1986) *Understanding small firms growth*, in *Small firms growth and development*, M. Scott, *et al.*, Editors, Blackmore Press: Dorset.
[6] Ulrich KT and Eppinger SD (2008) *Product Design and Development*.
[7] Frankelius P (2009) *Questioning two myths in innovation literature.* The Journal of High Technology Management Research, 20(1): p. 40-51.
[8] Trott P (2012) *Innovation Management and New Product Development*. Fifth Edition ed.: Prentice Hall.
[9] Tidd J, Bessant J, and Pavitt K (2005) *Managing Innovation: Integrating Technological, Market and Organizational Change*. Wiley.
[10] Christensen CM (1997) *The Innovator´s Dilemma*. New York: Harper Business.
[11] Backhaus JG (2003) *Joseph Alois Schumpeter: Entrepreneurship, Style and Vision*. Springer US.
[12] Ullman D, G. (2002) *The Mechanical Design Process.* New York: McGraw-Hill Higher Education.
[13] Lindahl M (2005) *Engineering Designers' Requirements on Design for Environment Methods and Tools*, in *Industrial Engineering and Management*, The Royal Institute of Technology: Stockholm.
[14] Lindahl M and Sundin E (2012) *Product Design Considerations for Improved Integrated Product/Service Offerings*, in *Handbook of Sustainable Engineering*, Springer.
[15] Andreasen M (1987) *Integrated Product Development*. Berlin: Springer.
[16] Bergman B and Klefsjö B (2003) *Quality from Customer Needs to Customer Satisfaction*. Lund: Studentlitteratur AB.
[17] Larsson H, Lindahl M, and Svensson N (2009) *Life cycle assessment of floor care - A comparative study of the Twister™ method and floor care methods using polish and wax*, in *LIU-IEI-R-- 09/0078--SE*: Linköping University, Sweden.
[18] Sandberg U and Mioduszewski P (2015) *Reduction of noise and rolling resistance by horizontal grinding of asphalt pavements*. in *Proc. of Inter-Noise*. San Francisco, California, USA.
[19] Lindahl M, Svensson N, Svensson BH, and Sundin E (2013) *Industrial cleaning with Qlean Water – a case study of printed circuit boards.* Journal of Cleaner Production, 47(0): p. 19-25.
[20] Kanda W, Sakao T, and Hjelm O (in press) *Components of business concepts for the diffusion of large scaled environmental technology systems.* Journal of Cleaner Production.